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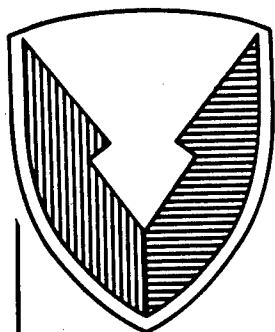
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C E N T E R

# Technical Report



No. 13523

LABORATORY AND FIELD TESTING OF THE

M1 EXHAUST DEFLECTOR

WITH PINTLE SHIELD

MARCH 1991

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20031219027

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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE Mar 91	3. REPORT TYPE AND DATES COVERED Final Sept 90 - Jan 91	
4. TITLE AND SUBTITLE Laboratory and Field Testing of the M1 Exhaust Deflector with Pintle Shield			5. FUNDING NUMBERS	
6. AUTHOR(S) Randal C. Gaereminck Marque A. Cryderman				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Commander U.S. Army Tank-Automotive Command (TACOM) ATTN: AMSTA-ZDS-IRV Warren, MI. 48397-5000			8. PERFORMING ORGANIZATION REPORT NUMBER  13523	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT  Approved for Public Release: Distribution is unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) <p>The U.S. Army is currently producing and testing a prototype exhaust deflector for M1 series tanks to be used during M1 to M1 towing operations. The deflector attaches to the engine exhaust grille and directs gases upward to prevent heat damage to the towed vehicle.</p> <p>The effort to redesign the exhaust deflector was accelerated beyond normal efforts because M1 recovery deficiencies surfaced with early units deployed to Southwest Asia. A "quick fix" solution for M1 towing capabilities was initiated at TACOM to overcome this deficiency. TACOM responded with a solution that included an immediate tasking to design, fabricate and field an improved exhaust deflector.</p> <p>This report describes the laboratory and field tests conducted by TACOM at Aberdeen Proving Grounds (APG) and at TACOM on a TACOM-designed exhaust deflector that hooks into place, without using mechanical fasteners.</p>				
14. SUBJECT TERMS  M1 Exhaust Deflector			15. NUMBER OF PAGES 34	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT  UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE  UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT  UNCLASSIFIED	20. LIMITATION OF ABSTRACT  SAR	



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## 1.0 ABSTRACT

The U.S. Army Tank-Automotive Command (TACOM) is currently producing and testing a prototype exhaust deflector for M1 series tanks to be used during M1 to M1 vehicle towing operations. The deflector attaches to the engine exhaust grille and directs gases upward to prevent heat damage to the towed vehicle. AM General, Inc. is the private contractor responsible for the preliminary design of the deflector.

The effort to redesign the exhaust deflector was accelerated beyond normal efforts because M1 recovery deficiencies surfaced with early units deployed to Southwest Asia. A "quick fix" solution for M1 towing capabilities was initiated at TACOM to overcome this deficiency. TACOM responded with a solution that called for use of the existing towbar with an improved clevis. The TACOM response to Southwest Asia also included an immediate tasking to design, fabricate and field an improved exhaust deflector.

Previous prototype deflectors had been constructed of stainless steel to resist corrosion. Hooks were provided to hang the deflector on the grille with four mechanical fasteners, mounted inside the deflector to connect the deflector firmly in place on the tank grille.

This report describes the laboratory and field tests conducted by TACOM at Aberdeen Proving Grounds (APG) and at TACOM on a TACOM-designed exhaust deflector that hooks into place, without using mechanical fasteners.

The information obtained from these tests provides a data base for further design upgrades of easily attached exhaust deflectors, as well as important technical information which can be used in designing future exhaust systems.

## 2.0 INTRODUCTION

This final technical report describes an improved TACOM-developed exhaust-heat deflector and pintle shield designed to enhance the M1 tank-towing capabilities.

The new exhaust-heat shield solved a critical problem encountered by soldiers in Southwest Asia when towing disabled M1-series tanks. The high temperatures made it impossible for troops to disconnect the towbar from the pintle after vehicle recovery was complete, without taking extraordinary precautions to prevent burns.

Quick field removal of the exhaust deflector to revert the M1 into a combat vehicle (with normal heat signature) was impossible, due to cool-down time, the poor location of the fastening hardware, and loss of bolts and attachment mounts.

The TACOM design allows for quick field conversion of an M1 from a combat vehicle to a tow vehicle, and back again to a combat vehicle.

### 3.0 BASIC DEFLECTOR DESIGN

Three grilles are required for the original field modification of the grille doors. One grille would be retained and used on the vehicle during normal combat operations. The field modification required the vertical support bars to be cut off from a second grille and the remaining vanes then welded onto a third grille at a 45-degree angle. The supporting bars of the second grille are then scrapped. The exhaust grill door was then fastened with bolts. These bolts frequently rusted in place or broke off during installation or removal.

The inability to install or remove the exhaust deflector without breaking the vane fastening bolts resulted in a requirement to continuously replace the bolts. Another problem was the replacement of the bolt attachment mounts which had to be welded in place. This suggestion to deflect heat was referenced in PM Magazine (Aug 90) which is included as Appendix A.

Prior to the installation or removal of the exhaust deflector, the engine had to be shut off and frequently had to cool for several hours or overnight. The cool-down period was necessary to allow the deflector and grille temperatures to reduce to a level that would prevent injury to the soldier.

This report discusses structural testing activities performed on several prototype deflectors.

### 4.0 TESTING

#### 4.1 AUG 90 YUMA TESTING

The AM General prototype deflector was taken to Yuma Proving Grounds (YPG) Arizona to run warm climate endurance and temperature testing. The objective was to get 100 to 200 miles of vehicle testing on rough terrain and to measure deflector maximum operating temperatures in a warm environment. All testing was conducted over a three-day period.

##### 4.1.1 THERMAL TESTS

Temperature-sensitive paint ranging from 300 to 900 degrees fahrenheit in 50-degree increments was applied to the deflector. The paint indicated that 750 degrees fahrenheit had been reached.

##### 4.1.2 BACK PRESSURE TESTS

Back pressure tests and flow tests of the basic prototype design were also included at YUMA.

##### 4.1.3 MECHANICAL INTERFERENCE TESTS

Tests were also performed on the AM General prototypes to check interference with angles of departure and point of contact of the towbar with the exhaust deflector.

##### 4.1.4 OVERALL TEST RESULTS AT YUMA PROVING GROUNDS

The AM General prototype deflector was tested on an M1 tank at YPG for a total of 156.8 miles. No heat damage was noticed during visual inspections. No failures of any kind were noted.

#### 4.2 CURRENT DESIGN CRITERIA

The improved TACOM-designed exhaust deflector consists of a welded three-piece design of sheet or strip carbon steel, .598-inches thick. The two J-hooks and two L-hooks that attach the deflector to the grille door were also made of sheet or strip carbon steel, .1345 inches diameter. Mild steel was used instead of the stainless steel that was used on early AM General prototypes, because mild steel is less expensive, available in the field, and easier to weld. The J-hook and L-hook design was developed to allow safe installation and removal of the deflector within seconds, even while the M1 tank engine continues to idle. The improved deflector (Figure 1) allowed for quick field conversion of an M1 from a combat vehicle to a tow vehicle, and back again to a combat vehicle.

##### 4.2.1 STRUCTURAL TESTS

Structural testing activities were performed on two TACOM-designed prototype deflectors to test the ability of the mild steel deflector and hook material to withstand the temperatures of the M1 engine exhaust. Additionally, the design of the hooks were tested at Aberdeen Proving Grounds to insure that the deflector did not detach during operation by the force of the engine exhaust, vehicle vibration, or while performing tank towing over cross-country terrain.

##### 4.2.2 TEST RESULTS - DESIGN CONSIDERATIONS

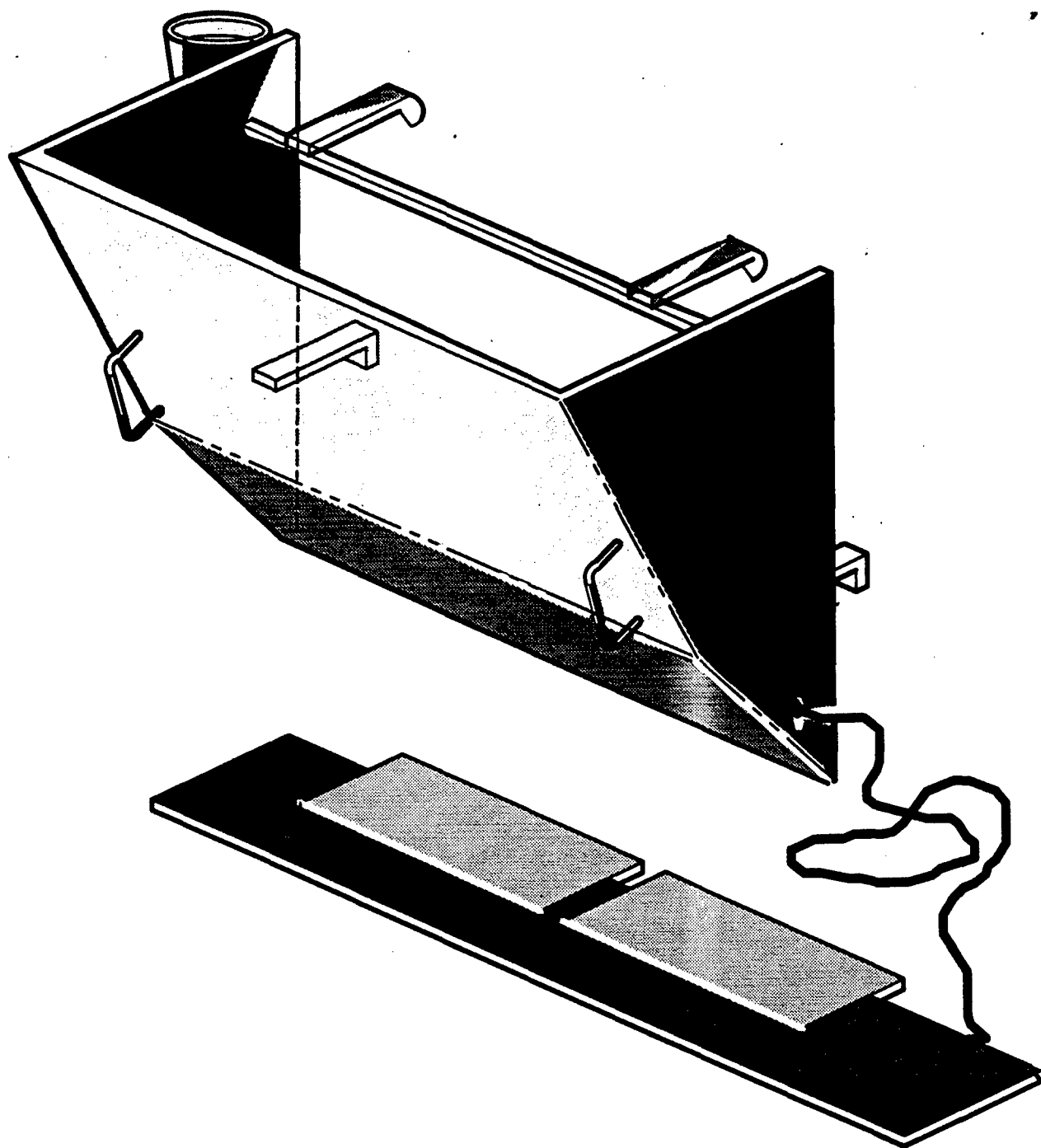
Since the design of the TACOM exhaust deflector did not deviate significantly from the basic dimension of the prototype deflector tested at YPG in Aug 90, the integrity of the Yuma back pressure and flow tests was also retained as background and baseline comparison data.

##### 4.2.3 FIELD TESTING

Field testing of the TACOM-designed exhaust deflectors was performed at Aberdeen Proving Ground (APG). The first test objective was to subject the deflector to the most severe "G" loading possible. To obtain this loading, the tank and towed load were driven around the Profile 4 and Perryman 3 courses, under dry, prepared course driving conditions. The deflectors were tested for a total of 78 miles; 18 miles on the Profile 4 course, 34 miles on Perryman 3, 5 miles on secondary roads, and 3 miles on pavement.

##### 4.2.4 FIELD TEST RESULTS

Field testing at APG resulted in no failures. The TACOM-designed deflector successfully withstood "G" loading of approximately 4.5 G's. The deflector did not detach from the tank grille from the



**FIGURE 1 - M1 EXHAUST DEFLECTOR  
WITH PINTLE SHIELD**

thrust of the engine exhaust. Also, the function of the deflector was not affected by vehicle vibration while towing. There were no failures due to heat damage.

The angle of the towbar, in relation to the exhaust deflector when mounted on the grille door, was also tested and observed. The angle of the towbar did not pose an interference problem with the deflector. The towbar lunette pin would make contact with the M1 grille door base prior to the towbar coming in contact with the deflector.

Pintle temperatures ranged from 325 to 360 degrees fahrenheit after towing operations on the various courses. The local ambient temperature at APG was 65-75 degrees fahrenheit.

#### 4.3 FIELD TEST CONCLUSIONS AND FIXES

##### 4.3.1 PINTLE SHIELD

During testing, the pintle reached temperatures ranging between 325 and 360 degrees fahrenheit, which made it impossible for the soldier to disconnect the towbar from the pintle after vehicle recovery was complete, without taking extraordinary precautions to prevent burns. In some operations, the pintle had to be disconnected with tools that allowed a safe distance between the soldier and the heat retained by the pintle. This deficiency was first detected during the testing of the exhaust deflector prototype and represented a Manpower and Personnel Integration (MANPRINT) deficiency.

The initial AM General prototype exhaust deflector failed to address the significant heat that the pintle retained during towing operations.

While testing the first TACOM-designed prototype deflector during towing operations, the soldier was unable to remove the towbar from a normal standing position and had to get under the vehicle and towbar to unhook it. This position was considered very unsafe. Field gloves (leather shell gloves, with wool insert) did not provide enough protection from the heat that the towbar and pintle retained after recovery operations. The soldier had to wrap the towbar with welding blankets or similar material, in order to safely remove the towbar. This operational test was captured in Figure 2.

As a result of the above testing, a new pintle shield was added as part of the TACOM-designed deflector. A steel pintle shield was fabricated to prevent exhaust gas from leaking below the deflector, onto the pintle. The pintle shield (Figure 1) was added as part of the M1 exhaust deflector package, attached to the deflector by a wire rope, 1/16th" diameter.

Testing of the pintle shield resulted in pintle temperatures of 180 degrees fahrenheit (idle) and 230 degrees fahrenheit (tach idle), a reduction of 60 - 120 degrees from the temperatures attained during early testing.



FIGURE 2 - SOLDIER LIFTING HEATED TOWBAR

#### 4.3.2 HANDLE WRAP

During testing at APG, the retained heat in the deflector handles reached temperatures in excess of 550 degrees, which made removal of the exhaust deflector by use of the handles very difficult after operations were complete. This deficiency was first detected during the testing of the exhaust deflector prototype and represented a MANPRINT deficiency. While testing the deflector during towing operations, the soldier was unable to remove the deflector without risk of severe burns.

The initial AM General prototype exhaust deflector did not have handles. Removal of this prototype was not generally possible until after the deflector was allowed to cool for several hours.

As part of the TACOM-designed deflector, handles were fabricated and then coated with high-temperature rubber, with an aramid liner. When the coating was added to the handles, removal of the deflector from the M1 tank could easily be accomplished, even without the necessity of field gloves. Removal without field gloves was done during APG and TACOM testing.

#### 4.3.3 THERMAL WRAP

During testing at APG, the radiant heat from the uninsulated flat surfaces of the deflector reached temperatures in excess of 550 degrees. These extreme temperatures made it difficult for the soldier to disconnect the towbar from the pintle after vehicle recovery and made removal of the exhaust deflector difficult after operations were complete. This deficiency was first detected during the testing of the exhaust deflector prototype and represented a MANPRINT deficiency.

While testing the deflector during towing operations at the Perryman test area at APG, the soldier was unable to remove the towbar without taking extraordinary precautions. The exhaust deflector alone did not provide enough protection from the radiant heat and from exhaust leakage that shot out from the left side of the deflector (directly above the pintle) during recovery operations and while at engine idle. The soldier had to lie on the ground to escape the exhaust that leaked from the side of the deflector while attempting to prepare the pintle for towbar attachment (Figure 3) or to connect or disconnect the tow bar to and from the pintle (Figures 4). The soldier's horizontal position was unsafe because the soldier was in direct line with the disconnected towbar, which weighs 340 lbs.

The initial AM General prototype exhaust deflector also failed to address the significant heat that radiates from the exhaust deflector during operations.

As part of the TACOM designed deflector, a thermal wrap was fabricated to reduce heat radiating from the deflector. The thermal wrap was fabricated in accordance with MIL-S-45351A(AT), which is the specification for Seal, Engine Shroud. The thermal wrap that was designed to reduce radiant heat (Figure 5), also included a tadpole one inch in diameter, 33 inches in length (Figure 6) that rivets into place along the left side of the

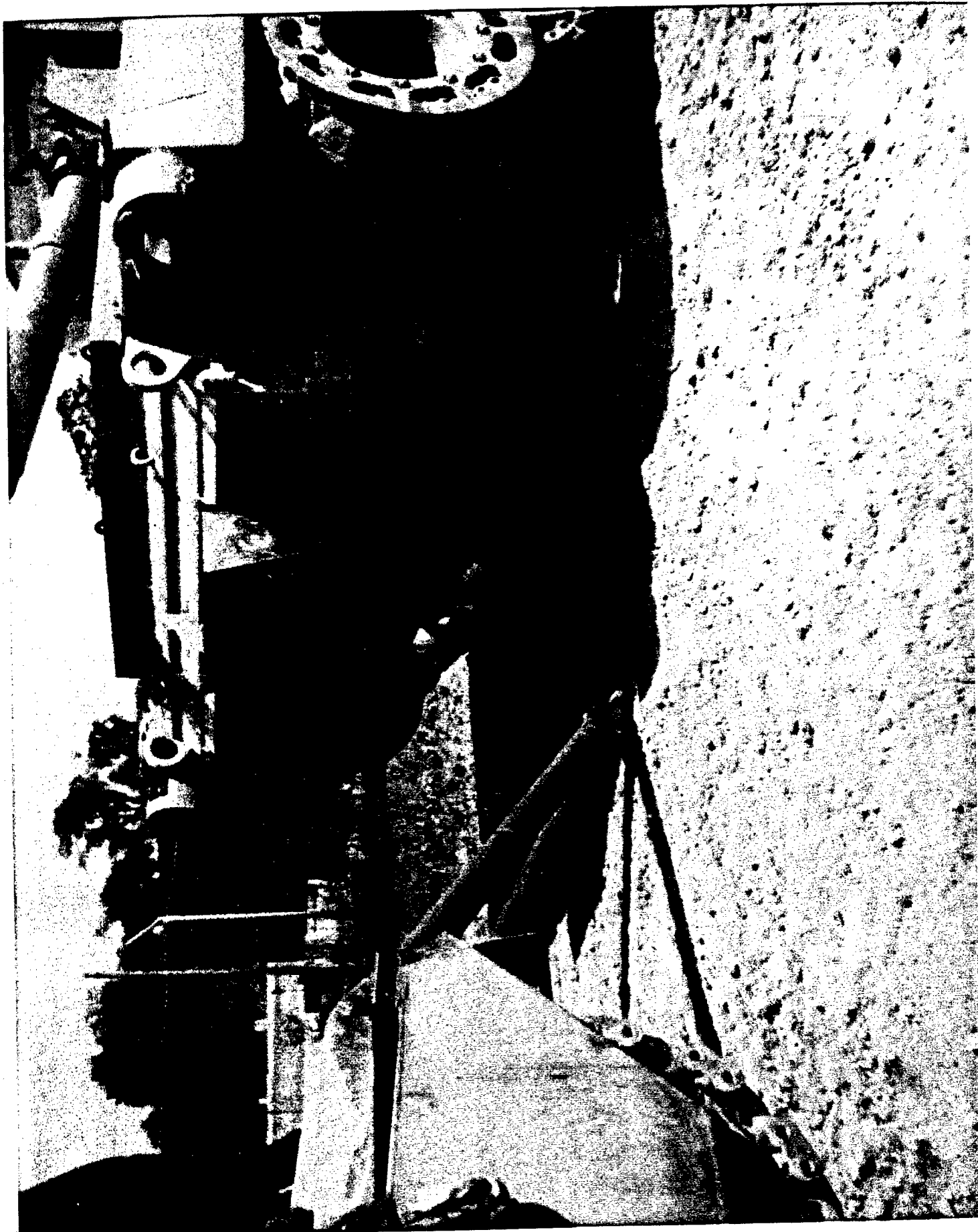


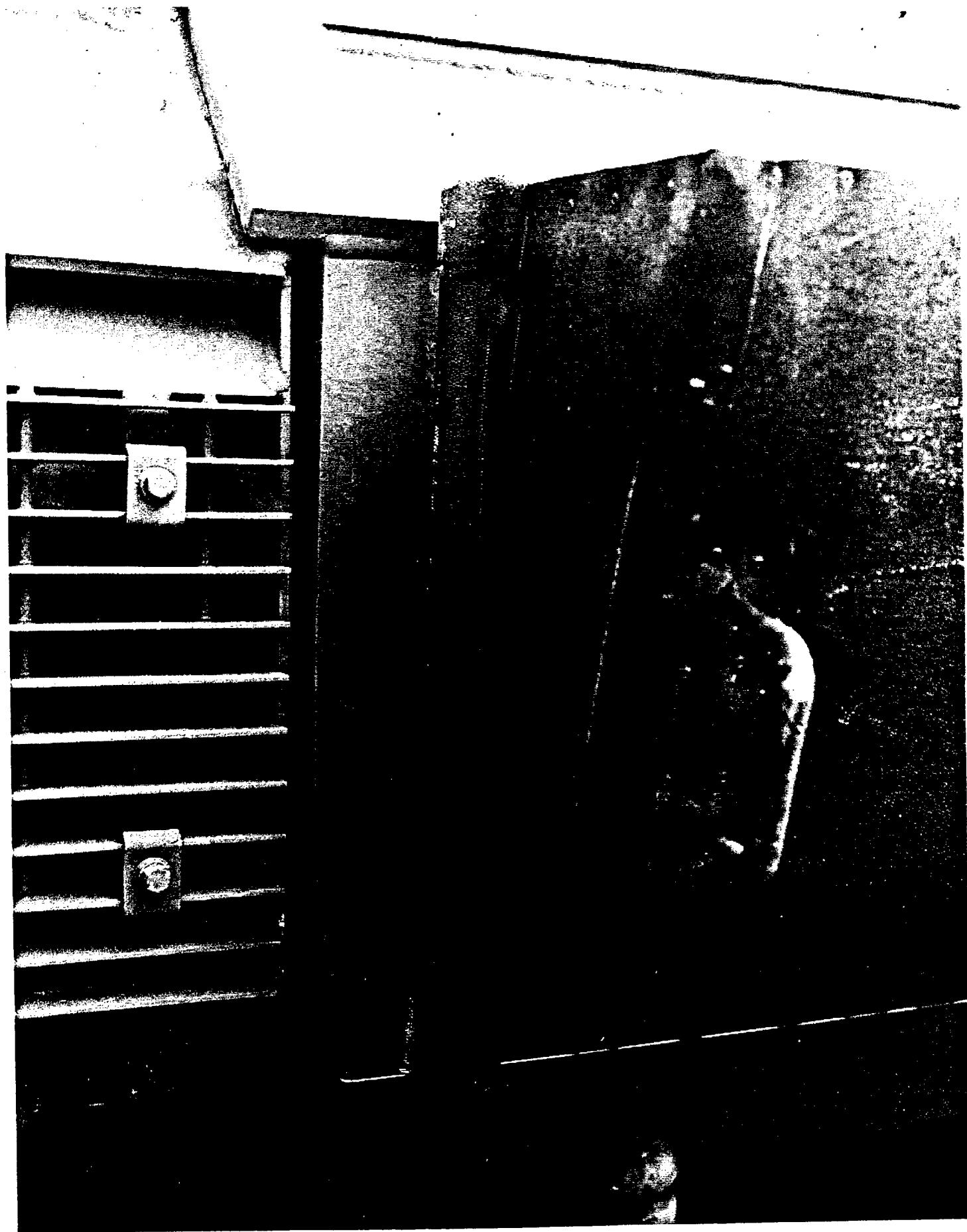
FIGURE 3 - SOLDIER PREPARING HEATED PINTLE  
FOR TOWBAR ATTACHMENT



FIGURE 4 - SOLDIER DISCONNECTING HEATED TOWBAR



**FIGURE 6 - INSTALLED M1 EXHAUST DEFLECTOR  
WITH BINTI E QUIET AND THERMAL WRAP**



**FIGURE 6 - THERMAL WRAP "TADPOLE" WITH  
INSTALLED M1 EXHAUST DEFLECTOR**

deflector.

The thermal wrap fabric is made of a combination of aramid/glass and wire inserted cloth, with silicone rubber on the inside. The wrap is coated on the outside with aluminum pigmented silicone compound and painted black. The thermal wrap was attached to the exhaust deflector with stainless steel rivets and washers over one-inch, high-temperature, fiberglass insulation. The tadpole is packed with stainless steel wire mesh material, then wrapped with the thermal wrap fabric and is then riveted in place. Testing of the TACOM-designed deflector, with the thermal wrap in place, resulted in radiant temperatures of 180 - 350 degrees fahrenheit, a reduction of over 200 degrees fahrenheit from the temperatures attained during early testing without the wrap.

Further testing with the wrap and tadpole demonstrated a reduction of radiant heat and shielding of the exhaust leak to the left side of the deflector (above the pintle). The thermal wrap enhances the soldier's ability to safely complete the recovery operations, and remove the exhaust deflector.

## 5.0 CURRENT AND FUTURE DEFLECTOR APPLICATIONS

Applications of the TACOM-designed M1 exhaust deflector with instant installation and removal, pintle shield, handle wrap, and thermal wrap include the following:

- Recovery: M1 towing of M1 vehicles.
- Shipboard Loading Operations, M1 operation in warehouses, and marine landing craft: All of these situations require that M1 engine exhaust gases be deflected to prevent heat damage to the walls of buildings and ships. The requirement for an exhaust deflector that can be installed and removed quickly can easily be met with the TACOM-designed deflector.
- Troops following behind M1 tanks: When the M1 tank heat signature is not important, the deflector can be used to allow troops to follow the M1 vehicles for additional combat protection.
- Clear Lane Automatic Marking System (CLAMS): Ft. Belvoir is researching the TACOM-designed exhaust deflector for use while operating the Clear Lane Automatic Marking System. The M1 engine exhaust currently melts the plastic luminescent markers. The use of the TACOM-designed exhaust deflector would prevent exhaust gases from melting the markers.
- Mine-Clearing Line Charge (MICLIC) The MICLIC Project Manager is currently reviewing test data on the TACOM-designed exhaust deflector for possible use on the M1 tank while towing the MICLIC. Current operation instructions for the MICLIC forbid towing the MICLIC with an M1 because of the intense exhaust heat and danger of direct exhaust temperatures over 750 degrees fahrenheit. These extreme temperatures pose a volatile environment for transporting the MICLIC's C4 explosive charges. Testing has proved out the capability to tow the MICLIC with an

M1, with the TACOM-designed exhaust deflector.

Field Fix Package: A field fix package is currently being developed to furnish soldiers instructions that are sufficient to build deflectors in the field.

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

The test results from both the laboratory and field testing of the improved M1 exhaust deflector indicate that the TACOM-designed deflector can easily be installed and removed and also improves the conditions of the soldier.

As a result of the field testing and the TACOM safety release, this deflector has been fielded on a limited basis for M1 towing in Southwest Asia. Additionally, testing continues at Ft. Knox, KY and Ft. Irwin, CA.

Feedback of information for the deflectors in use, both from TACOM testing and from the field, has resulted in high praise for the TACOM-designed M1 exhaust deflector, with pintle shield, handles and thermal wrap.

Some of the most important information collected was the temperature data from the M1 to M1 towing tests. Prior to these field tests, there had been no information available indicating the actual temperatures that the soldier was exposed to when recovering a vehicle without the use of an adequate exhaust deflector.

The TACOM-designed exhaust deflectors have demonstrated the ability to be quickly installed and removed, without gloves, on M1-series tanks running at idle and tach idle.

Instructions for the fielded deflectors are included as Appendix B. Additionally, a full safety release (MANPRINT) was obtained on the improved M1 exhaust deflector from the TACOM Safety Office.



APPENDIX A  
DEFLECT HEAT - PM MAGAZINE



# Deflect Heat During Towing

**P**revent heat damage to vision blocks, hatch covers and other front end components when towing an M1 with another M1 by using a heat deflector.

You can make a deflector that attaches to the towing M1's exhaust grate.

Plans for the deflector are on Pages 2-3 through 2-8 of TB 43-0001-39-1 (Jan 88). If your local TACOM Logistic Assistance Representative doesn't have a copy, write to Half-Mast.



**APPENDIX B**

**INSTRUCTIONS TO INSTALL  
EXHAUST DEFLECTOR ASSEMBLY**



## OPERATION UNDER UNUSUAL CONDITIONS

### INSTALL EXHAUST DEFLECTOR ASSEMBLY

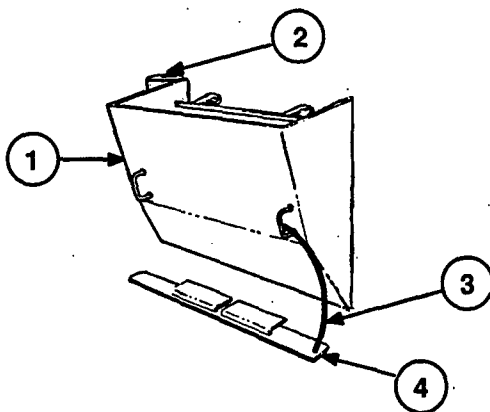
#### NOTE

This procedure is required for use on the M1 Abrams tank family of vehicles when towing another M1 Abrams tank. Installation of the engine exhaust deflector assembly is necessary to prevent damage to the infrared vision blocks, driver's hatch seals, and other vital equipment of the vehicle being towed.

When installed on the vehicle, the exhaust deflector assembly directs the hot engine exhaust gases away from the vehicle pintle and tow bar during towing.

#### WARNING

Be alert for exhaust fumes from tow tank when engine is running. Exhaust fumes from tow tank are very hot and can burn you. Wear field jacket and work gloves.



A. Inspect exhaust deflector (1), deflector gasket (2), attachment cable (3), and pintle shroud (4) for serviceable condition and security of attachment.

#### NOTE

For improved towing clearance when towing an M1 vehicle with another M1, use the improved towing clevis available with Tow Bar Assembly NSN 2540-01-267-2912.

#### CAUTION

To prevent heat damage to main gun tube, do not traverse turret over top deck when exhaust deflector is installed and vehicle engine is operating.

## OPERATION UNDER UNUSUAL CONDITIONS

## INSTALL EXHAUST DEFLECTOR ASSEMBLY - Continued

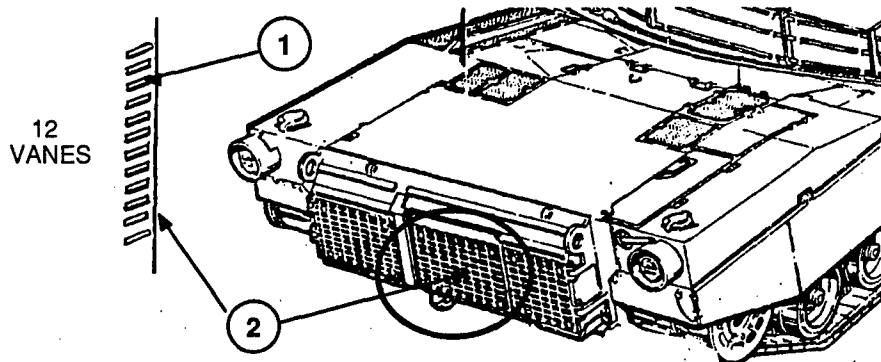
## WARNING

**Be alert for exhaust fumes from tow tank when engine is running. Exhaust fumes from tow tank are very hot and can burn you. Wear field jacket and work gloves.**

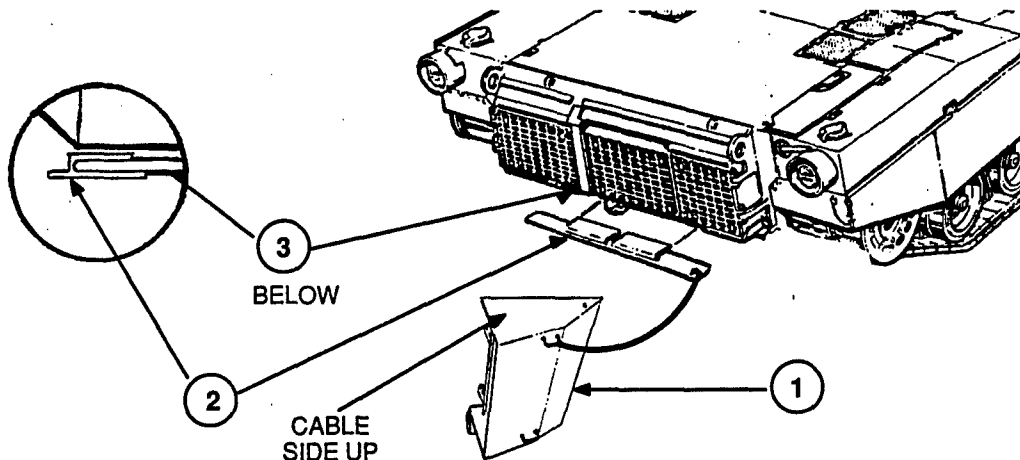
## NOTE

**M1 vehicles equipped with Auxiliary Power Units (APU's) are not recommended for use as towing vehicles. The vehicle tow hook may interfere with the APU during vehicle right turns.**

**The exhaust deflector cannot be installed on vehicle rear grille doors having more than 12 vanes.**



B. Before trying to install the exhaust deflector, count the number of vanes (1) in rear grille door (2) of the vehicle to be used for towing.



**C. Position the exhaust deflector assembly (1) on the ground, on its side close to the towing vehicle, with the exhaust deflector assembly pintle shroud (2) cable side facing up as shown. Install pintle shroud (2) over vehicle rail (3) as shown and push shroud (2) firmly into place.**

## OPERATION UNDER UNUSUAL CONDITIONS

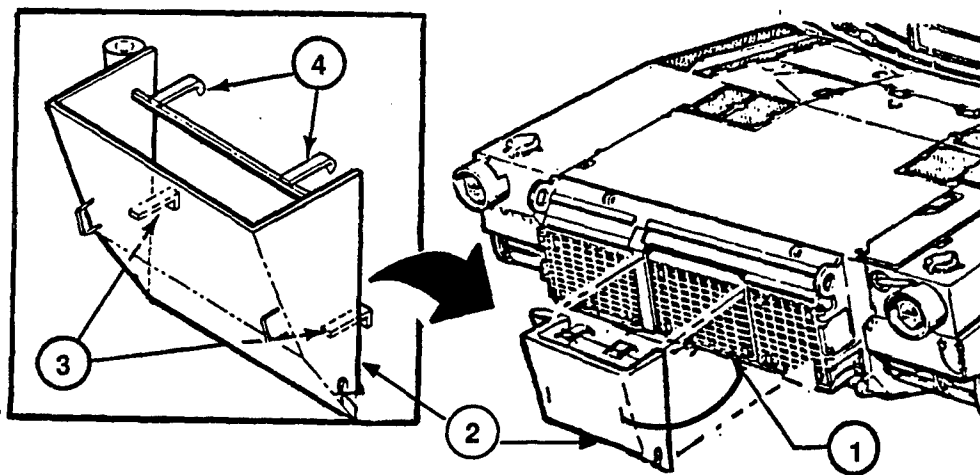
### INSTALL EXHAUST DEFLECTOR ASSEMBLY - Continued

#### CAUTION

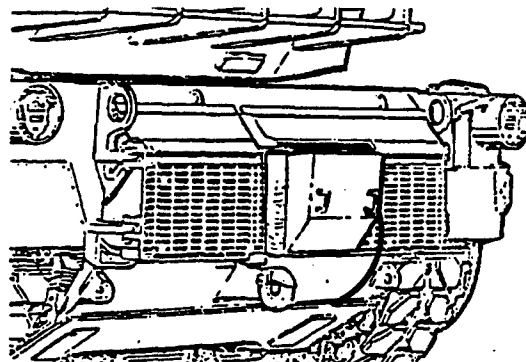
To prevent heat damage to main gun tube, do not traverse turret over top deck when exhaust deflector is installed and vehicle engine is operating.

#### WARNING

Be alert for exhaust fumes from tow tank when engine is running. Exhaust fumes from tow tank are very hot and can burn you. Wear field jacket and work gloves.



D. Lift deflector (2) up parallel with and into rear grille door (1) so that hooks (4) are attached to the top vane of the grille door and hooks (3) are secured completely over grille vanes that fall in line when the top hooks (4) are in place.



E. Check that deflector is securely in place and bottoms against rear grille door and pintle shroud underneath.

## OPERATION UNDER UNUSUAL CONDITIONS

### INSTALL EXHAUST DEFLECTOR ASSEMBLY - Continued

#### CAUTION

To prevent heat damage to main gun tube, do not traverse turret over top deck when exhaust deflector is installed and vehicle engine is operating.

#### NOTE

Installation of the exhaust deflector does not replace the requirements indicated in the M1 Abrams tank technical manual for tank towing. Refer to TM 9-2350-255-10-2 or TM 9-2350-264-10-2 as required.

F. Tow disabled vehicle (refer to TM 9-2350-255-10-2 or TM 9-2350-264-20-2).

#### END OF TASK

#### REMOVE EXHAUST DEFLECTOR ASSEMBLY

#### **WARNING**

Be alert for exhaust fumes from tow tank when engine is running. Exhaust fumes from tow tank are very hot and can burn you. Wear field jacket and work gloves.

- A. Lift exhaust deflector up and away from rear grille until hooks are free of grille vanes.
- B. Set deflector near enough to vehicle to allow removal of pintle shroud.

#### **WARNING**

To prevent personnel injury, make sure gloves are worn during removal of pintle. Engine will be hot after operation

- C. Pull pintle shroud from tank frame rail.
- D. Stow exhaust deflector assembly in the same location as the tow bar which was used for towing.

#### END OF TASK

## ACKNOWLEDGMENTS

As stated in the abstract, a "quick fix" solution for M1 towing capabilities was initiated at TACOM to overcome M1 recovery deficiencies that surfaced with early units deployed to Southwest Asia. The effort to enhance the M1 tank-towing capability and field an adequate exhaust deflector, from concept to first delivery was accomplished within 90 days.

The authors wish to acknowledge the contributions of the following individuals for their efforts in meeting the immediate needs of Operation Desert Storm.

### TACOM

#### Design & Manufacturing Technology

Ken Green	Alex Sneddon
Larry Barczyk	Don Henning
Gregg Carter	Randy Mckelvin
Nick Logreco	Leonard McBurney
Al Marciniok	Rich Line
Al Loew	Larry Serpien
James Vitale	Dennis O'Connell
Santiago Ponti	Shirley Wimley
Dave Diamond	Martin Terry
Bill Jones	Russ Aleo
Bob Downs	Ed Lewandowski
Gary Ward	Cliff Welles

Larry Berry

#### Maintenance Directorate

Leo Parks                      John Teregan

#### Product Assurance and Test

Joe Warner

#### Advanced Systems, Concepts & Planning Directorate

John Roberts

#### Aerofab Co., Inc.

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